NONNATIVE SPECIES MONITORING AND CONTROL IN THE UPPER/MIDDLE SAN JUAN RIVER: 2011

FINAL REPORT

PREPARED FOR:

SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

PREPARED BY:

BOBBY R. DURAN, JASON E. DAVIS AND ERNEST TELLER SR.

U.S. FISH AND WILDLIFE SERVICE

NEW MEXICO FISH AND WILDLIFE CONSERVATION OFFICE

3800 COMMONS N.E.

ALBUQUERQUE, NM 87109

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SUBMITTED TO:

SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

BIOLOGY COMMITTEE

3 JULY 2012

EXECUTIVE SUMMARY

1. A total of 29,881 channel catfish and 274 common carp were removed from river miles (RM) 166.6 – 52.9 in 775.4 hours of electrofishing.

2. Channel catfish CPUE from PNM Weir to Hogback Diversion was the highest observed CPUE since 2006 but was significantly lower ($p < 0.05$) than values observed in 2001 and 2004.

3. Channel catfish CPUE from Hogback Diversion to Shiprock Bridge was similar to CPUE in 2005-2010 but was significantly lower ($p < 0.05$) than values observed in 2003 and 2004.

4. We observed a higher abundance of juvenile channel catfish in each of the removal sections. Increase juvenile channel catfish abundance is suspected to be influenced by upstream immigration from areas of higher abundance.

5. Channel catfish CPUE, all life stages combined, from Shiprock Bridge to Mexican Hat was significantly higher than CPUE values observed in 2008 and 2010 but were significantly ($p< 0.001$) lower than values observed in 2009.

6. Similar to 2009 and 2010 juvenile channel catfish CPUE significantly increased ($p < 0.05$) near the Mancos River confluence (RM 122.5), and the McElmo Creek confluence (RM 100.0).

7. Mean common carp CPUE was <0.6 fish/hour in all three removal sections.

8. A total of 1,748 Colorado pikminnow and 1,576 razorback sucker were collected during our efforts in 2011

9. The majority of razorback sucker captures occurred within 10 RM's of the stocking location at RM 158.6.

10. Twenty-seven Colorado pikeminnow >400 mm total length (TL) were collected in 2011 including nine adult fish >500 mm TL.

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INTRODUCTION

The introduction and establishment of nonnative fishes has been recognized as one of several factors leading to the decline of native fish populations. Introductions of nonnative fishes in western North American riverine systems can affect native fish populations due to the depauperate nature of these systems and the evolution of native species in the absence of predators (Minckley and Douglas 1991). The control of nonnative fishes has become an increasingly important management action in programs aimed at the recovery of federally protected species (Mueller 2005). The establishment of channel catfish *Ictalurus punctatus* and common carp *Cyprinus carpio* has been identified as a detriment to the recovery of Colorado pikeminnow *Ptychocheilus lucius* and razorback sucker *Xyrauchen texanus* (USFW 2002a, b) and their control has specifically been identified as a management element in the San Juan River Basin Recovery Implementation Program's Long Range Plan (U.S. Fish and Wildlife Service 2011):

San Juan River Recovery Implementation Program's Long Range Plan (2011 Draft):
- ***Element 3.*** *Interactions between native and nonnative fish species*
  - ***Goal 3.1-*** *Control of problematic nonnative fishes as needed*
    - ***Action 3.1.1-*** *Develop, implement, and evaluate the most effective strategies for reducing problematic nonnative fishes.*
      - ***Task 3.1.1.1-*** *Mechanically remove nonnative fish to achieve objectives.*

Removal efforts by U.S. Fish and Wildlife Service, New Mexico Fish and Wildlife Conservation Office (NMFWCO) began on a limited basis in 1998 with intensified efforts beginning in 2001. These efforts focused on a 7.6 river mile (RM) reach near Fruitland, NM. Location of intensive removal efforts was influenced by information on adult fish distribution and abundance (Ryden 2000). These data indicated that numbers of channel catfish and common carp were lower upstream of PNM Weir (RM 166.6) and that the majority of nonnative fishes within Geomorphic Reaches 6 and 5 (Bliesner and Lamarra 2000) were adult fish. High densities of large, adult nonnative fishes and the presence of water diversion structures that served as potential impediments to upstream fish movement in these upper sections helped guide management decisions on where intensive removal efforts would focus.

Efforts in 2011 marked the eleventh consecutive year of intensive nonnative removal from PNM Weir to Hogback Diversion (RM 166.6 - 159.0). In addition to this section, intensive nonnative removal from Hogback Diversion to Shiprock Bridge (RM 158.8 – 147.9) has been conducted since 2003. Based on observed increases in channel catfish abundance (Ryden 2007, 2008), efforts were expanded in 2008 to include intensive removal from Shiprock Bridge to Mexican Hat, UT (RM 147.9 – 52.9). In 2011, intensive nonnative removal conducted by NMFWCO encompassed 113.7 river miles.

Study objectives were as follows:

1. Continue data collection and mechanical removal of large-bodied nonnative fish during main channel and rare fish monitoring efforts.

2. Implement riverwide mark/recapture to determine exploitation rates for channel catfish

3. Evaluate distribution and abundance patterns of nonnative species to determine effects of mechanical removal

4. Characterize distribution and abundance of endangered fishes in the upper and middle reaches of the San Juan River

STUDY AREA

Intensive nonnative removal efforts in 2011 focused on three individual sections of the San Juan River, New Mexico, Colorado, Utah, encompassing 113.7 river miles (RM). Sections sampled included PNM Weir to Hogback Diversion (RM 166.6 – 159.0), Hogback Diversion to Shiprock Bridge (RM 158.8 – 147.9), and Shiprock Bridge to Mexican Hat, Utah (RM 147.9 – 52.9) (Figure 1). Nonnative removal was conducted in portions of Geomorphic reaches 6 – 2 (Bliesner and Lamarra 2000). PNM Weir to Hogback Diversion was exclusively located in Geomorphic Reach 6, Hogback Diversion to Shiprock Bridge encompassed portions of both Geomorphic reaches 6 and 5, and Shiprock Bridge to Mexican Hat was in reaches 5 – 2.

METHODS

Nonnative fishes were collected using raft-mounted electrofishing units (Smith-Root 5.0 GPP). Electrofishing settings were standardized to run pulsed direct current (PDC) on high range. Percent of power was adjusted by raft operators to maintain an output current of 4 amperes. Rafts sampled near each shoreline and netters attempted to collect any nonnative fishes observed. In addition to nonnative species, native rare fishes were netted during all efforts. Electrofishing proceeded downstream and fish were processed at designated stops.

All nonnative fishes or a representative sub-sample (blind grab) were measured (nearest 1 mm) for total (TL) and standard length (SL) and weighed (nearest 5 g) for mass. Seconds of electrofishing were recorded to determine effort at the end of each sampling unit. These sampling units ranged from two - three miles depending on the Section. All nonnative fishes collected were removed from the river. Two electrofishing rafts sampled for three consecutive days/trip from PNM Weir to Hogback Diversion and Hogback Diversion to Shiprock Bridge. During sampling from Shiprock Bridge to Mexican Hat, a total of four electrofishing rafts were used. Two rafts began sampling one hour prior to the remaining rafts resulting in the completion of two electrofishing passes per trip.

Native rare fishes collected were immediately placed in a live well or five gallon bucket separate to that of nonnative fishes. Native fish were measured (nearest 1 mm), weighed (nearest 5 g) and checked for the presence of a Passive Implant Transponder (PIT) tag. If a PIT tag was detected, the number was recorded and it was noted that the fish was a recaptured fish. If the presence of a PIT tag was not detected and the fish was > 150 mm TL, a 134.2 kHz PIT tag was implanted and the capture status was recorded as a new capture (Davis 2010).

A mark and recapture study from Shiprock Bridge to Mexican Hat for channel catfish was initiated in 2011. The purpose of this effort was to attain exploitation rates and generate a population estimate. The tagging trip began on April 7, 2011 but due to the possible government shut down, crews were directed to pull off the river after the first day of sampling at RM 139.0. The trip resumed at RM 118 (Four Corners Bridge) on April 12th and tagging continued through April 17th ending at RM 52.9. All channel catfish and common carp ≥ 200 mm TL were tagged with individually numbered anchor tags and released back to the river. All tagged fish were also adipose fin clipped in case of tag loss. A population estimate was calculated for adult channel catfish and common carp using a Lincoln-Petersen estimate with Chapman's Correction. An estimate was calculated for adult fish and only included recaptured tagged fish collected during the first trip conducted after tagging. Fish that moved upstream of Shiprock Bridge were not included in the calculation of exploitation rates or the population estimate. Exploitation rates, *u*, were estimated as the proportion of recaptured marked fish to marked fish (Deroba et al. 2005),

$$u = R/M$$

where, R represents number of recaptured fish and M represents number of marked fish

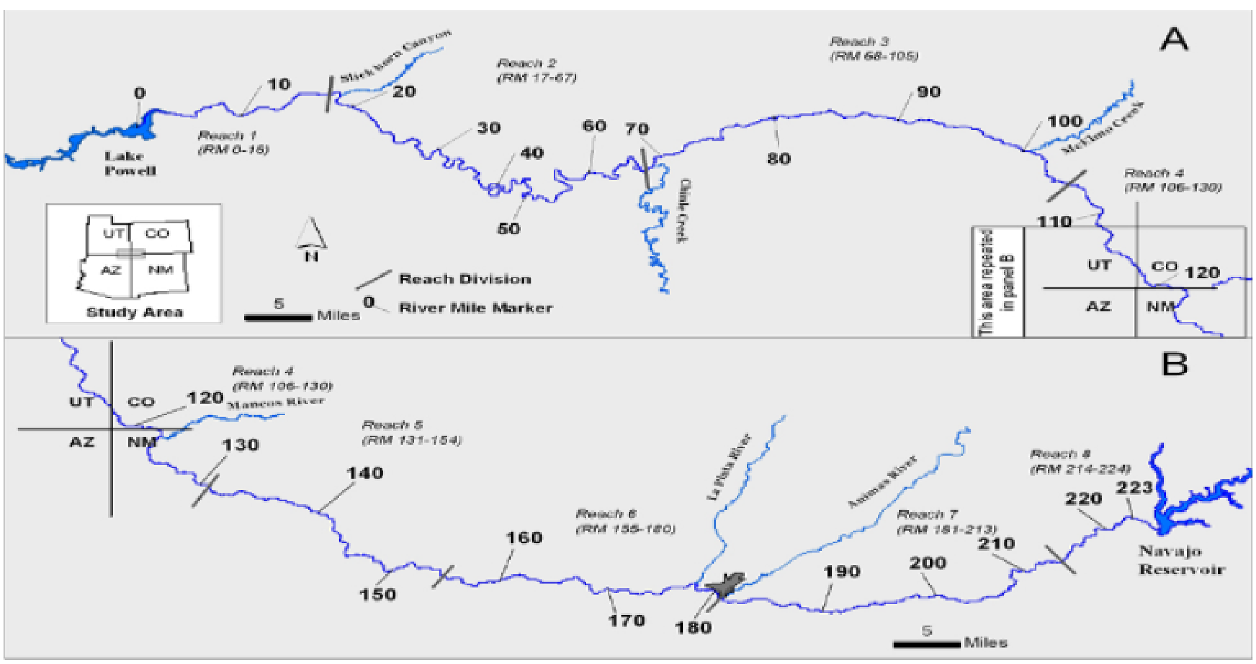

Figure 1. Map of study area – map provided by UNM MSB

All available capture data were analyzed independently by section. For example, catch rates among years from PNM to Hogback, Hogback to Shiprock and Shiprock to Mexican Hat were compared only with the same section and not among sections. However, inferences on the influence of nonnative fish abundance among sections were made. Determination of trends in distribution and abundance, mean catch rates (fish per hour of electrofishing; CPUE) and standard error (± 1 SE) were calculated using the software package SPSS version 13.0 (2004). Species CPUE was calculated as the total number of fish collected divided by the total effort of sampling (hours of electrofishing). Data were summarized by section, trip, and year.

If CPUE data met the assumptions of normality and equality of variance, a One Way Analysis of Variance (ANOVA) was conducted to determine if significant differences existed. Multiple pairwise comparisons using Bonferroni post hoc tests were used to determine where significant differences existed. If data were heteroscedastic, and transformations were unsuccessful in attaining equal variance, an ANOVA on ranked data (Kruskal-Wallis) was conducted with Nemenyi post hoc tests to determine where significant differences existed (Zar 1996). Significance levels were set at $P<0.05$.

RESULTS

PNM WEIR TO HOGBACK DIVERSION (RM 166.6 – 159.0)

A total of 263 channel catfish and 21 common carp were removed from this section during two trips (June and August) and 30.6 hours of electrofishing (Appendix A-1). Additional nonnative fishes removed from the section included rainbow trout *Oncorhynchus mykiss*, brown trout *Salmo trutta*, bullhead catfishes *Ameiurus spp.,* largemouth bass *Micropterus salmoides,* green sunfish *Lepomis cyanellus*, and bluegill *Lepomis macrochirus*. No striped bass *Morone saxatilis* or walleye *Sander vitreus* were collected or observed.

CHANNEL CATFISH

Channel catfish CPUE was < 1.0 fish/hour during the June trip and significantly increased to 13.0 fish/hour in August (Mann-Whitney; $U = -3.499$; $p<0.001$) (Figure 2). In 2011, the mean channel catfish CPUE for all life stages combined was 6.7 fish/hour (Figure 3).

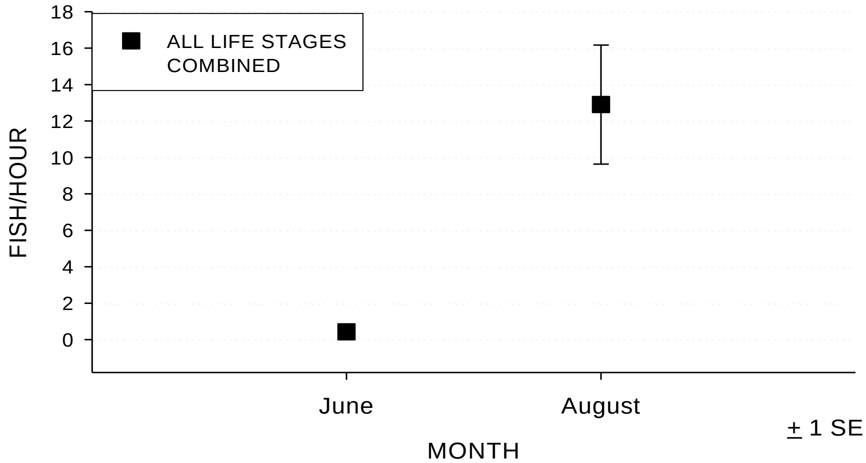

Figure 2. Channel catfish CPUE (fish/hour) by trip within the PNM Weir to Hogback Diversion Section; 2011. Error bars represent ± 1 SE.

Mean channel catfish CPUE in 2011 was similar to catch rates observed from 2002-2003 and 2005-2010 but was significantly lower than CPUE in 2001 and 2004 (ANOVA; $F_{(10, 548)} = 10.155$; $p < 0.05$).

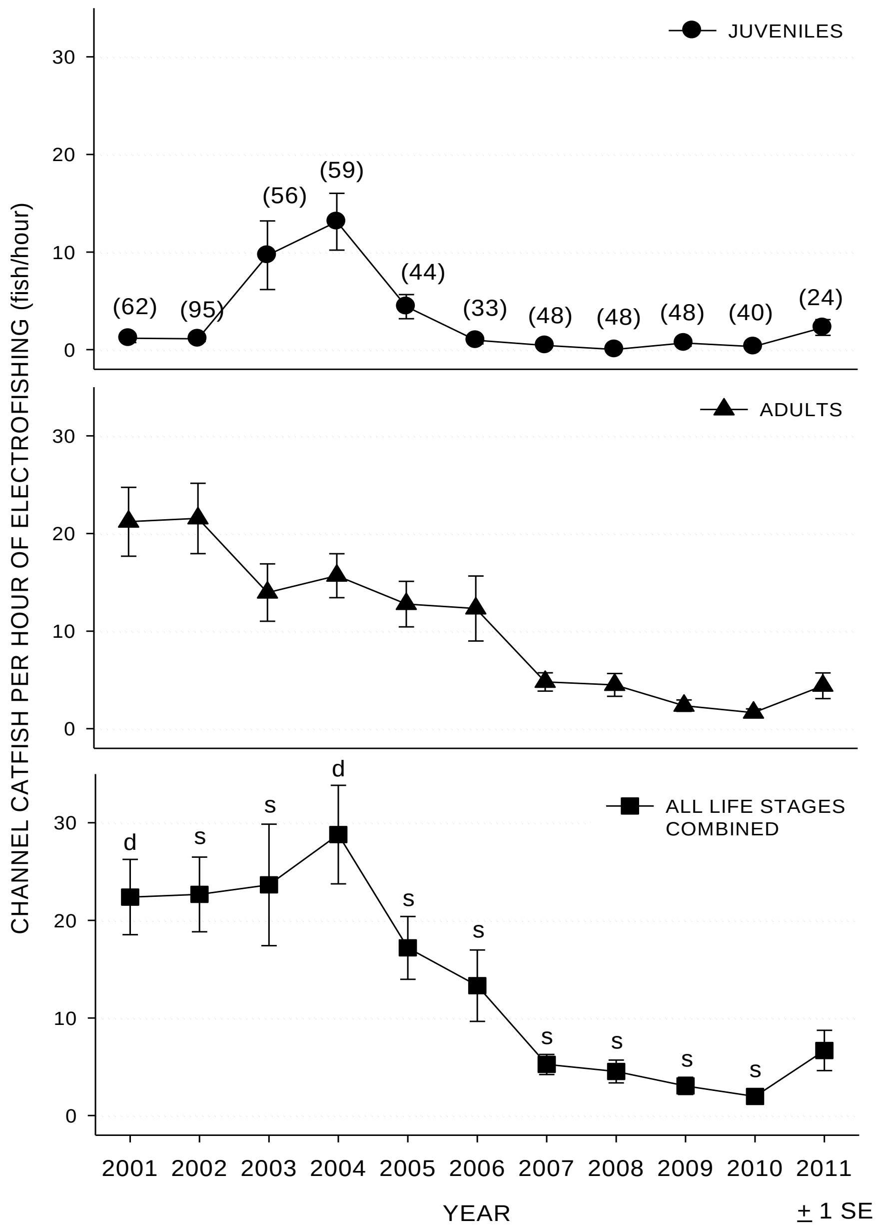

Figure 3. Channel catfish CPUE (fish/hour) by year, PNM Weir to Hogback Diversion; 2001-2011. Error bars represent ± 1 SE. Letters represent comparisons among years (Nemenyi post-hoc). Letter above data points represent statistical comparisons of that individual year to 2011. A “d” means that year was statistically different than 2011 and an “s” means that year was similar to 2011. Sample size presented parenthetically.

The mean TL of channel catfish in 2011 was 341mm and lengths ranged from 222 to 576 mm TL (Figure 4). The length frequency distribution of channel catfish in 2011 differed compared to patterns observed in 2010. The majority of fish in 2011 were small sub-adult fish and newly recruited adults. The percentage of large adults, 425 – 575 mm TL, that composed the majority (64.3%) of catch in 2010, was reduced in 2011 (Figure 4). This reduction in large adults influenced the decreased mean TL observed in 2011.

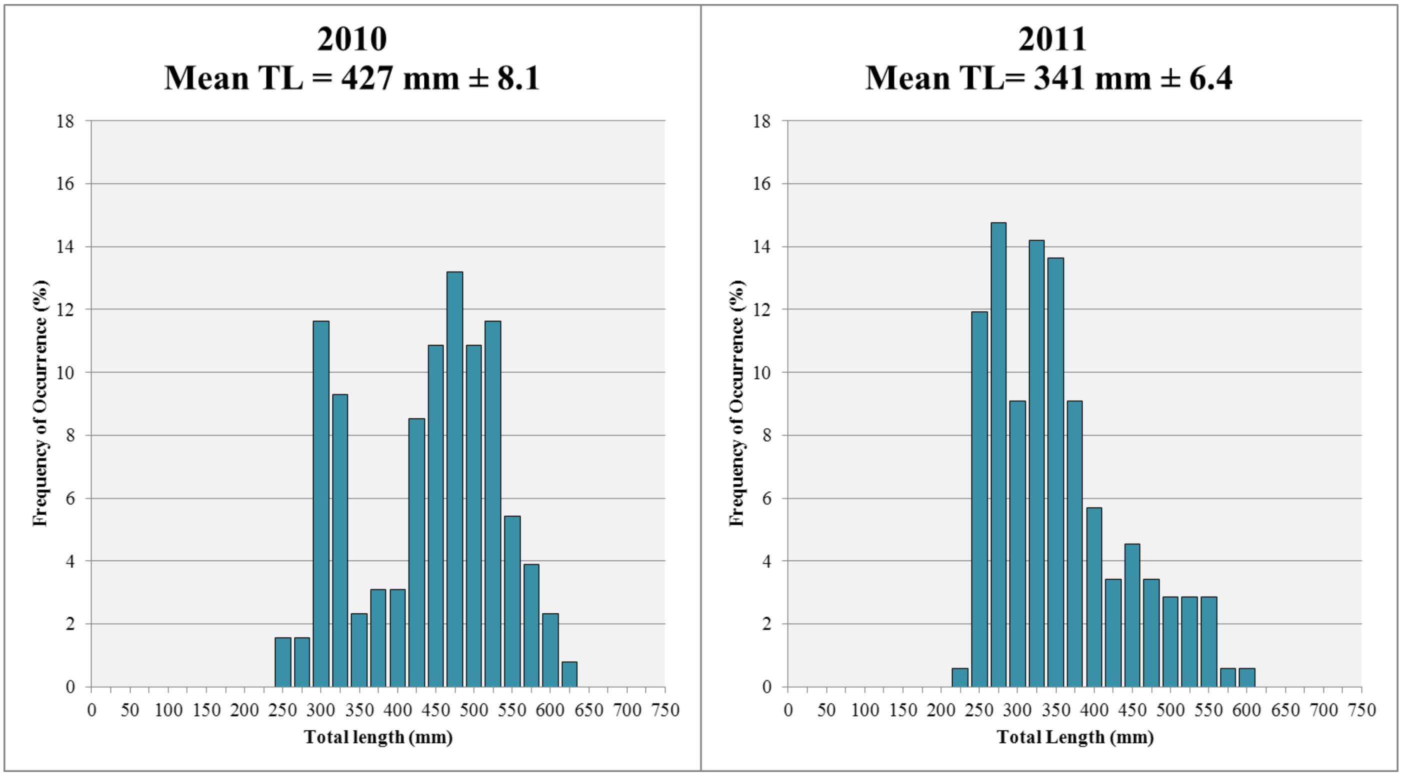

Figure 4. Mean TL (1 SE) and length frequency histograms for channel catfish collected from PNM Weir to Hogback Diversion; 2010 -2011. The y-axis represents percentage (%) of catch and the x-axis represents total length.

COMMON CARP

Common carp CPUE varied little during the two trips in 2011 (Figure 5). Catch rates were ≤ 1.0 fish/hour during each trip and ranged from 0.2 fish/hour in June to 1.0 fish/hour in August. Mean common carp CPUE, all life stages combined, in 2011 was 0.6 fish/hour (Figure 6).

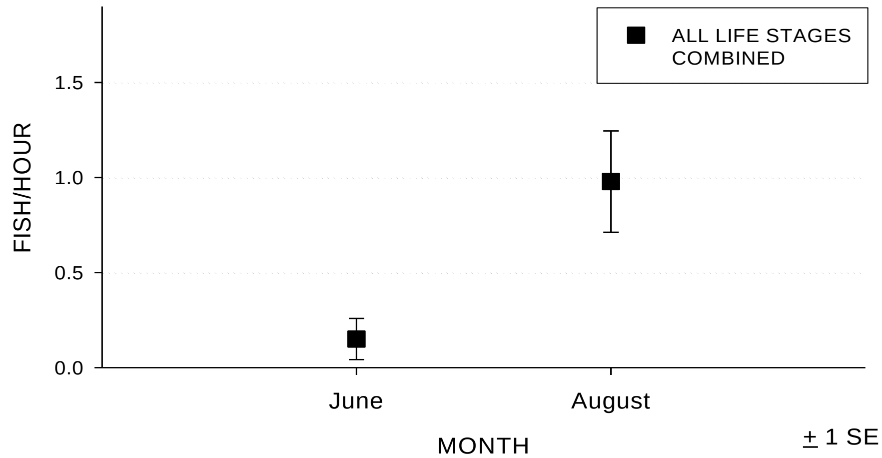

Figure 5. Common carp CPUE (fish/hour) by trip within the PNM Weir to Hogback Diversion Section; 2011. Error bars represent ± 1 SE.

Comparison of common carp CPUE among years showed a continuing decline in catch rates resulting in 2011 having the lowest observed catch rate since nonnative removal began in 2001. Catch rates in 2011 were similar to values observed in 2008-2010 but were significantly lower than all previous years (ANOVA; $F_{(10,548)} = 62.642$; $p < 0.05$) (Figure 6). Common carp mean CPUE was < 1.0 fish/hour for the third consecutive year. Common carp continue to be uncommon in all collections within this section.

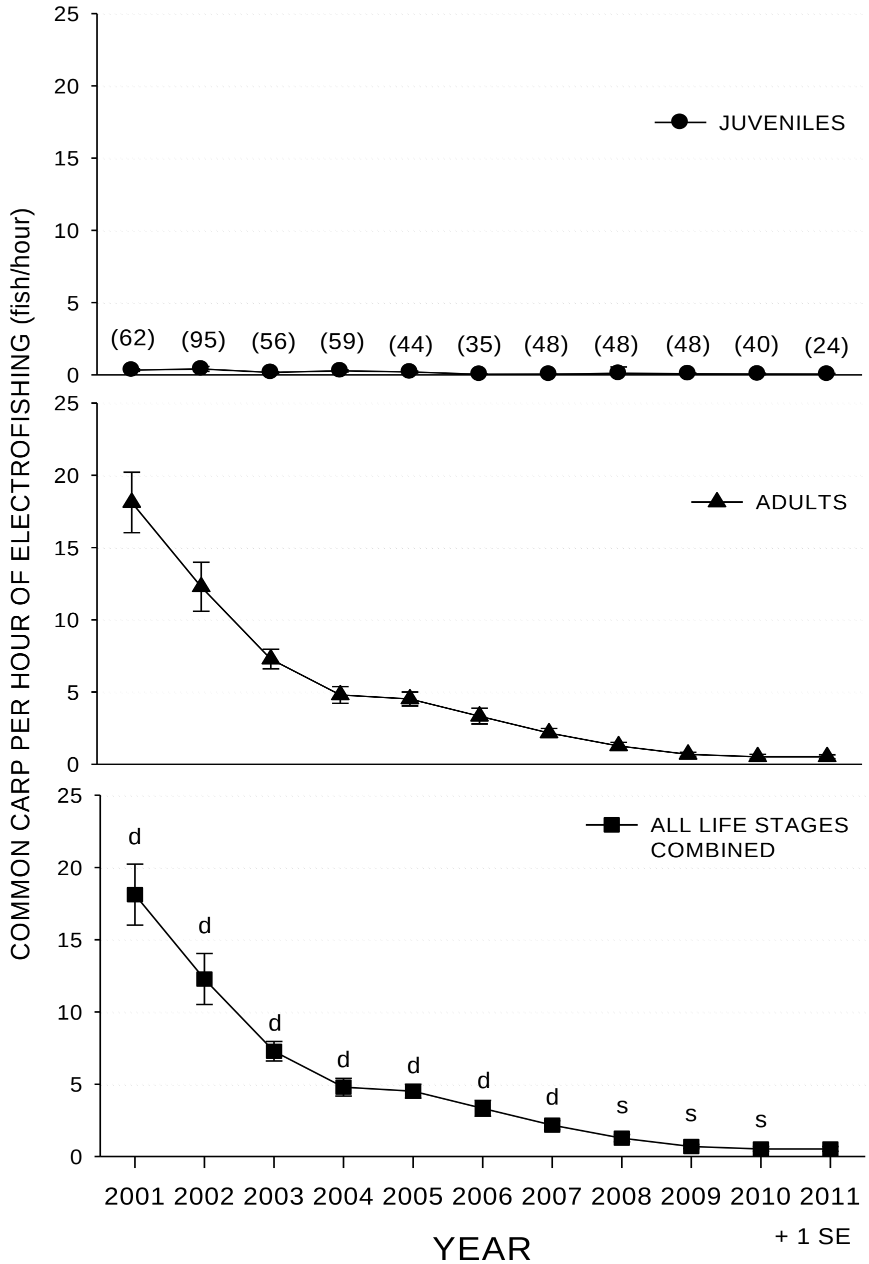

Figure 6. Common carp CPUE) fish/hour by year, PNM Weir to Hogback Diversion; 2001-2011. Error bars represent ± 1 SE. Letters represent comparisons among years (Nemenyi post-hoc). Letter above data points represent statistical comparisons of that individual year to 2011. A "d" means that year was statistically different than 2011 and an "s" means that year was similar to 2011. Sample size presented parenthetically.

HOGBACK DIVERSION TO SHIPROCK BRIDGE (RM 158.8 – 147.9)

A total of 741 channel catfish and 36 common carp were removed during three trips (March, July and August) and 67.8 hours of electrofishing (Appendix A-2). In addition to channel catfish and common carp, other nonnative fishes collected included rainbow trout, brown trout, bullhead catfishes, largemouth bass, green sunfish and bluegill.

CHANNEL CATFISH

Channel catfish CPUE in 2011 ranged from 0.7 fish/hour to 15.2 fish/hour (Figure 7). Catch rates observed in March were significantly lower than all other trips (ANOVA; $F_{(2, 85)} = 82.667$; $p < 0.05$). Catch rates were similar between the July and August trips. The mean channel catfish CPUE in 2011, all life stages combined, was 10.8 fish/hour (Figure 8).

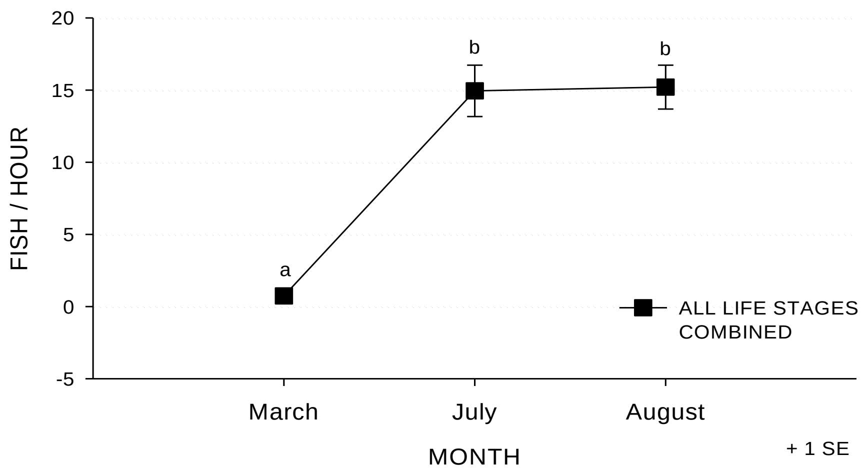

Figure 7. Channel catfish CPUE (fish/hour) by trip within the Hogback Diversion to Shiprock Bridge Section; 2011. Error bars represent ± 1 SE. Letters represent comparisons among trips (Nemenyi post-hoc). Similar letters represent that significant differences did not exist and unlike letters indicate that significant differences were detected among comparisons.

Channel catfish CPUE was significantly lower than that which was observed at the initiation of intensive removal in 2003. Channel catfish CPUE in 2003 was 57.7 fish/hour compared to 10.8 fish/hour in 2011 (ANOVA; $F_{(8, 1,143)} = 60.442$; $p < 0.001$) (Figure 8). Catch rates in 2011 were similar to values observed in 2005-2010 but were significantly lower than values observed from 2003-2004.

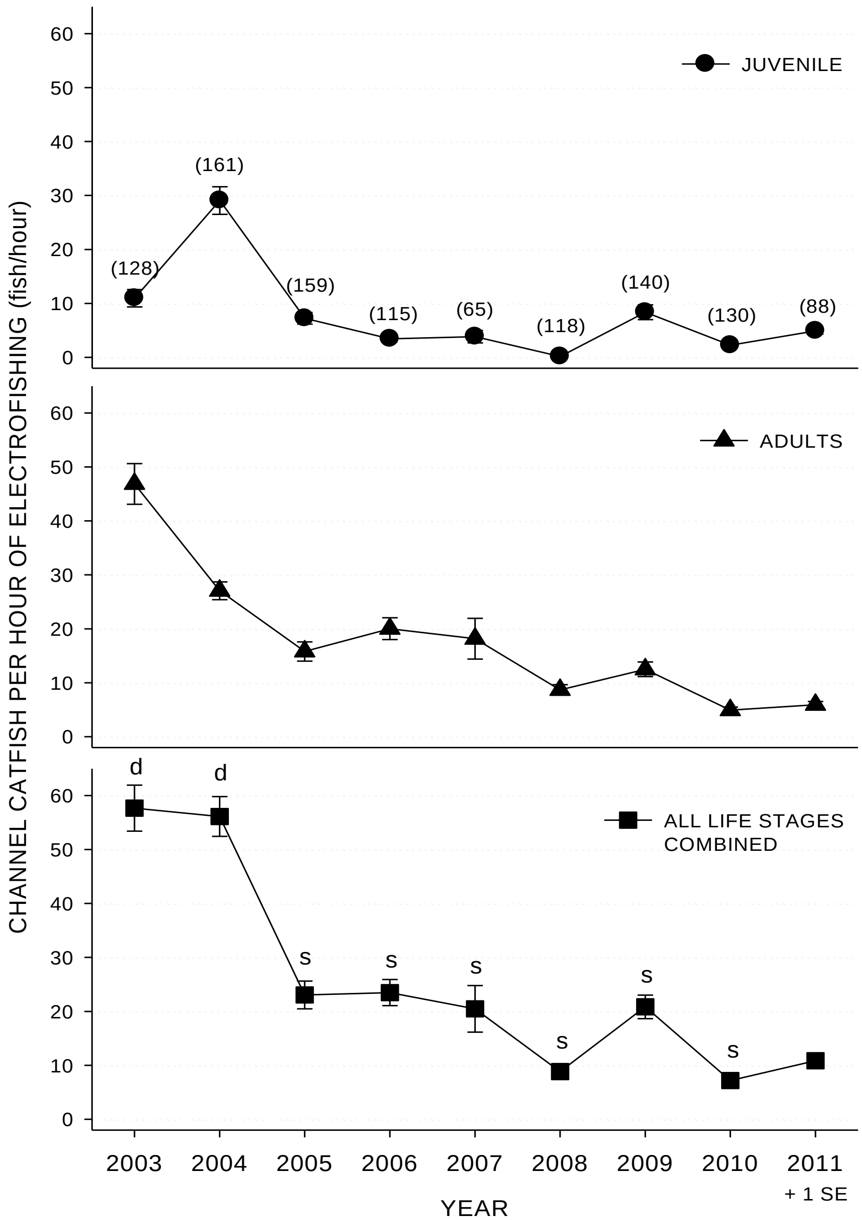

Figure 8. Channel catfish CPUE (fish/hour) by year, Hogback Diversion to Shiprock Bridge; 2003-2011. Error bars represent ± 1 SE. Letters represent comparisons among years (Nemenyi post-hoc). Letter above data points represent statistical comparisons of that individual year to 2011. A “d” means that year was statistically different than 2011 and an “s” means that year was similar to 2011. Sample size presented parenthetically.

The mean TL of channel catfish in 2011 was 318 mm (Figure 9) and lengths ranged from 154 to 656 mm TL. Similar to the length frequency distribution from PNM Weir to Hogback Diversion, the 2011 size structure was highly influenced by juvenile and sub- adult fish and newly recruited adults. The bimodal distribution of channel catfish observed in 2010 was not present in 2011 and can be attributed to fewer fish from 400-550 mm TL being collected in 2011(Figure 9).

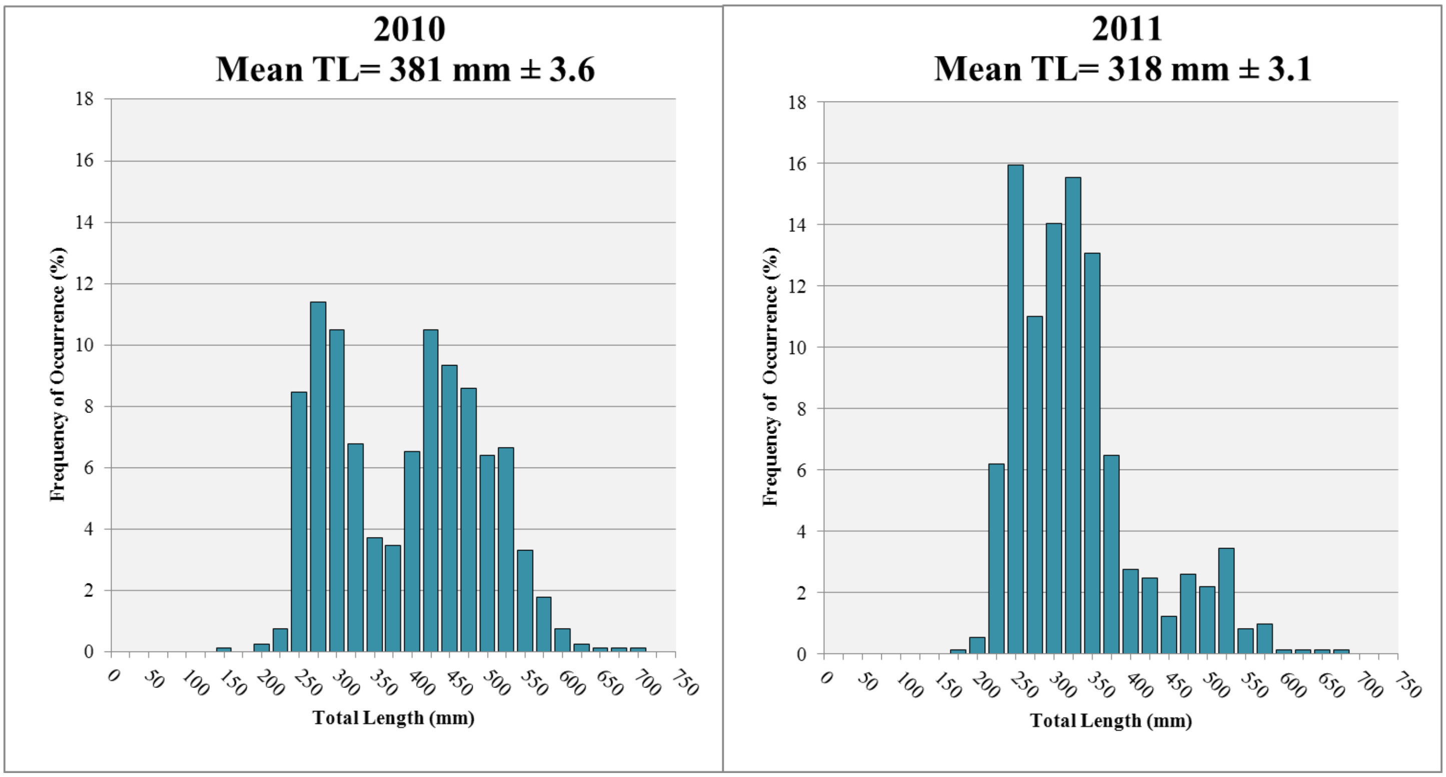

Figure 9. Mean TL (1 SE) and length frequency histograms for channel catfish collected from Hogback Diversion to Shiprock Bridge; 2010 - 2011. The y-axis represents percentage (%) of catch and the x-axis represents total length.

COMMON CARP

Common carp catch rates, by trip, were < 1.0 fish/hour and varied little among the three trips in 2011 (Figure 10). Mean common carp CPUE, all life stages combined, in 2011 was 0.5 fish/hour (Figure 11).

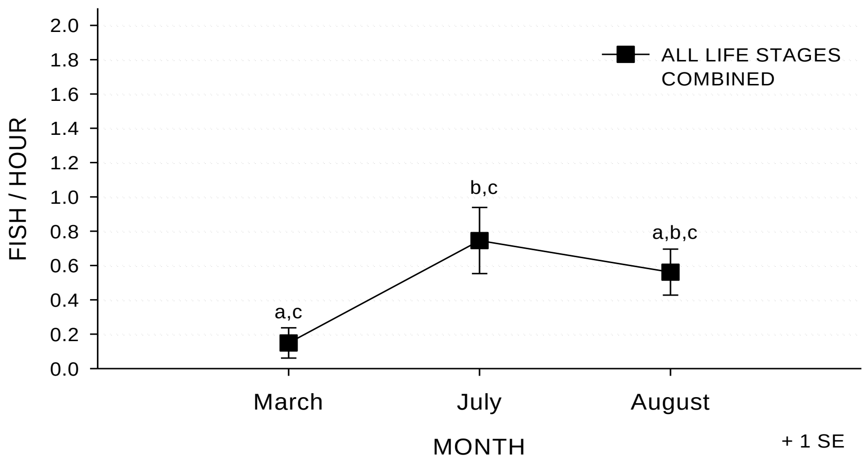

Figure 10. Common carp CPUE (fish/hour) by trip within the Hogback Diversion to Shiprock Bridge Section; 2011. Error bars represent ± 1 SE. Letters represent comparisons among trips (Nemenyi post-hoc). Similar letters represent that significant differences did not exist and unlike letters indicate that significant differences were detected among comparisons.

Common carp CPUE has declined significantly since the initiation of intensive removal in 2003. Common carp CPUE in 2003 was 29.0 fish/hour compared to 0.5 fish/hour in 2011 (ANOVA; $F_{(8, 1,143)} = 148.731$; $p < 0.001$; (Figure 11). Common carp continue to be infrequently collected from Hogback Diversion to Shiprock Bridge and 2011 marked the second consecutive year that common carp CPUE was < 1.0 fish/hour.

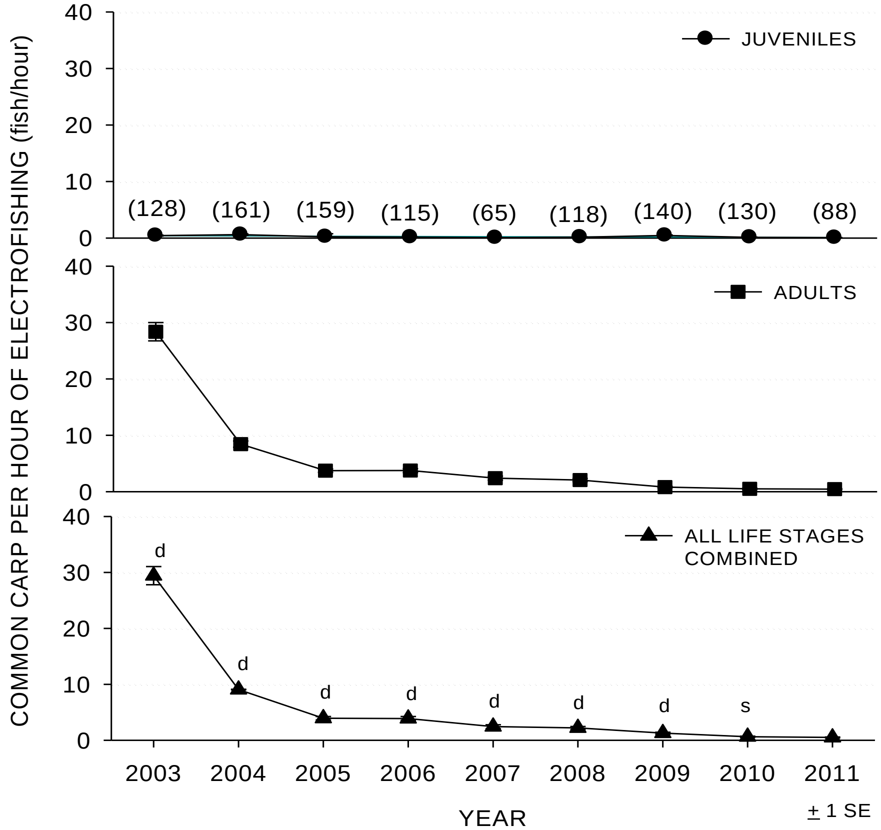

Figure 11. Common CPUE (fish/hour) by year, Hogback Diversion to Shiprock Bridge; 2003-2011. Error bars represent ± 1 SE. Letters represent comparisons among years (Nemenyi post-hoc). Letter above data points represent statistical comparisons of that individual year to 2011. A "d" means that year was statistically different than 2011 while an "s" means that year was similar to 2011. Sample size presented parenthetically.

SHIPROCK BRIDGE TO MEXICAN HAT (RM 147.9 - 52.9)

One tagging trip and three removal trips (April/May, July, and September) were conducted from Shiprock Bridge to Mexican Hat in 2011. During removal trips, a total of 19,495 channel catfish and 166 common carp were removed in 521.8 hours of electrofishing. Nonnative fish removal also took place in conjunction with FWS Colorado River Fishery Project's annual fall monitoring in September, resulting in the removal of an additional 9,382 channel catfish and 41 common carp in 155.3 hours of electrofishing. For the year, a total of 28,877 channel catfish and 207 common carp were removed during 677 hours of electrofishing in this section (Appendix A-3). Other nonnative fishes removed included brown trout, rainbow trout, bullhead catfishes, green sunfish, bluegill and largemouth bass. No striped bass or walleye were collected or observed.

MARK AND RECAPTURE

A total of 1,334 channel catfish and 20 common carp were collected and implanted with individual alphanumeric anchor tags during a trip from Shiprock Bridge to Mexican Hat, UT. Total length measurements were taken from all fish that were tagged to determine exploitation rates by size classes. Adult channel catfish, $\geq$ 300mm TL, composed 69% of the total number of channel catfish tagged (N=917), while juvenile channel catfish composed 31% (N=417). In addition to nonnative fishes collected, we captured 99 Colorado pikeminnow and 109 razorback sucker during the tagging trip.

Exploitation rates for channel catfish were generated for each size class by individual trips and total exploitation for the year (Table 1). The highest total exploitation rate by trip (13.6%) was observed during the first post-tagging trip. Total exploitation rates declined during the remaining three removal trips and averaged 2.3 %. The combined exploitation rate for all size classes and trips was 19.4 %. Total exploitation rates ranged from 10.3 % for juvenile channel catfish to 41.7 % for fish > 600 mm TL. Twelve channel catfish (1 juvenile, 11 adults) moved an average of 65 river miles upstream and were recaptured in the two removal sections upstream of Shiprock Bridge. No tagged channel catfish were captured during nonnative fish removal trips conducted by Utah Department of Wildlife Resources (UDWR) downstream of Mexican Hat, Utah. Since channel catfish in this section are not a closed population, we are violating the assumption that fish are not moving in or out of this section. Due to unknown variables such as tag loss, mortality, emigration and immigration, it was suggested that we base our exploitation estimate only for the first post-tagging trip. For reporting purposes we decided to leave all four trip exploitation rates and total exploitation rates in the table to show the decline in exploitation rates as the year went on, which could be due to the unknown variables. Although one trend that is present in the first trip exploitation rates as well as the subsequent three trip exploitation rates is that we have higher exploitation rates for larger channel catfish compared to juvenile channel catfish.

Table 1. Channel catfish exploitation rates from Shiprock Bridge to Mexican Hat, UT. 2011. Numbers in parentheses in the Mark Pass row represent total number of channel catfish tagged in that size class. Numbers in parentheses in the Trip 1-4 rows represent total number of channel catfish recaptured for that size class and trip and percentage is the exploitation rate for that size class during that trip.

	Total Length (mm) of Channel Catfish at Time of Tagging					
	200-299 mm TL	300-399 mm TL	400-499 mm TL	500-599 mm TL	600+ mm TL	Total
Mark Pass	(417)	(402)	(369)	(134)	(12)	(1334)
Trip 1 April/May	8.2%	15.7%	17.6%	12.7%	16.7%	13.6%
	(34)	(63)	(65)	(17)	(2)	(181)
Trip 2 July	0.3%	2.1%	3.3%	6.8%	-	2.3%
	(1)	(7)	(10)	(8)	-	(26)
Trip3 Sept	0.8%	2.2%	3.1%	4.6%	10%	2.2%
	(3)	(7)	(9)	(5)	(1)	(25)
Trip 4 Sept (Fall Monitoring)	1.3%	1.6%	3.9%	3.8%	22.2%	2.5%
	(5)	(5)	(11)	(4)	(2)	(27)
Middle section Total	10.3%	20.4%	25.7%	25.4%	41.7%	19.4%
	(43)	(82)	(95)	(34)	(5)	(259)

During the tagging trip, 917 adult, $\geq$ 300 mm TL, channel catfish were tagged. On the first removal trip in April/May, 2,919 adult fish were captured including 147 anchor-tagged fish. The Lincoln-Petersen population estimate for adult channel catfish from Shiprock Bridge to Mexican Hat, UT was 18,111 (95% CI = 15,220-21,002; CV=7.98%, SE=1,446).

A total of 20 common carp were tagged during the mark pass. On the first removal trip a total of 72 common carp were captured including five anchor tagged fish. The population estimate for common carp, $\geq$ 200 mm TL, was 255 (95% CI = 70-439; CV=36.21%, SE=92.2).

REMOVAL TRIPS

CHANNEL CATFISH

Channel catfish CPUE, all life stages combined, varied among trips in 2011. The highest mean CPUE of 55.4 fish/hour was observed during the September Fall Monitoring trip, and the lowest mean CPUE of 25.5 fish/hour was observed during the July trip (Figure 12). The September Fall Monitoring trip also had significantly higher juvenile channel catfish catch rates compared to the previous three trips (ANOVA; $F_{(3, 518)} = 8.612$; $p < 0.001$).

Similar to 2009 and 2010, juvenile catch rates increased as sampling proceeded downstream. Juvenile catch rates were < 7.0 fish/hour from RM's 147.9 to 130 and peaked at 61.0 fish/hour from RM's 70 to 60 (Figure 13). In each of the previous three years, catch rates significantly increased near RM 122.5, the Mancos River confluence, and near RM 100 , the McElmo Creek confluence (ANOVA; $F_{(9, 512)} = 32.181$; $p < 0.001$).

In 2011, the mean channel catfish CPUE, all life stages combined, was 42.7 fish/hour and was significantly higher than the 2010 CPUE of 28.0 fish/hour (ANOVA; $F_{(2, 1,602)} = 113.465$; $p < 0.001$). Adult CPUE was similar to rates observed in 2010 while juvenile CPUE significantly increased from 15.3 fish/hour in 2010 to 30.5 fish/hour in 2011 (ANOVA; $F_{(3, 2,123)} = 191.967$; $p < 0.001$) (Figure 14).

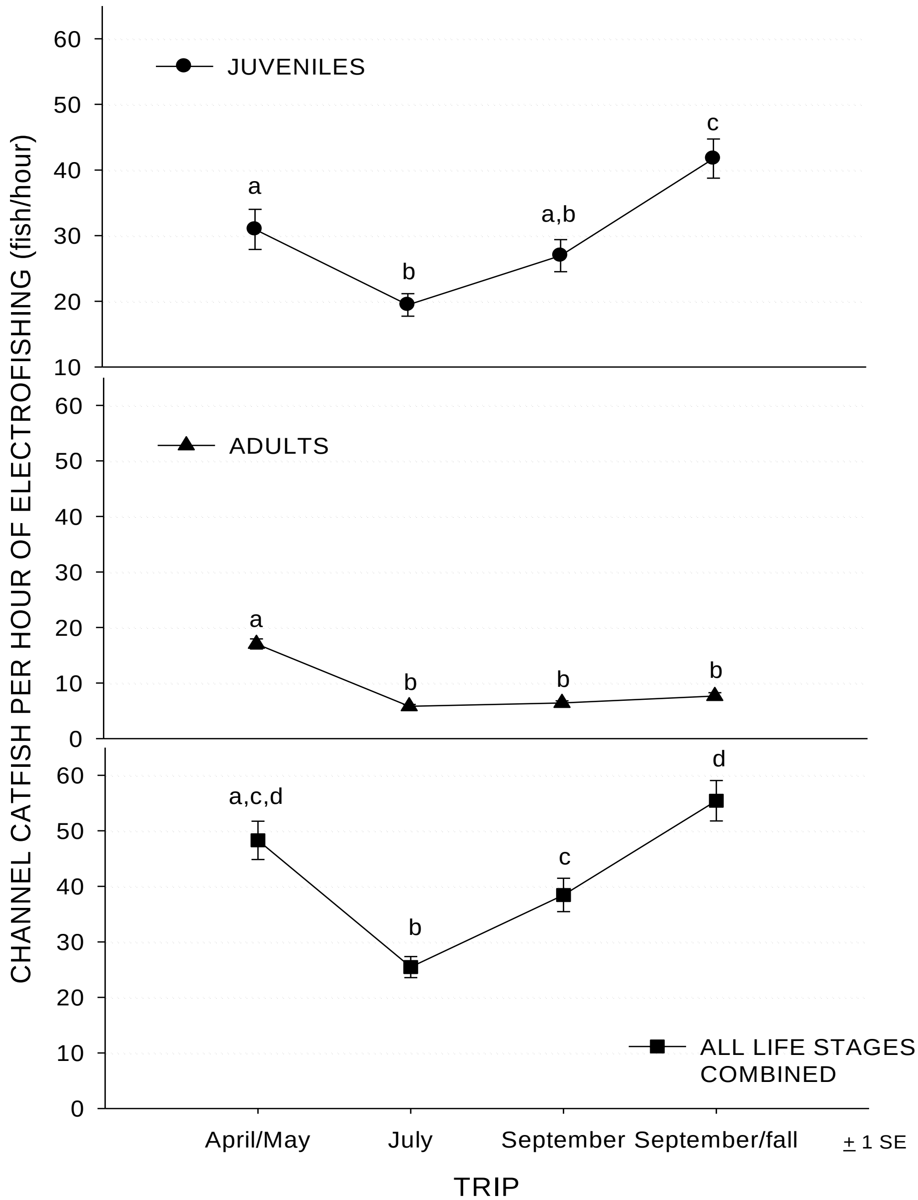

Figure 12. Channel catfish CPUE (fish/hour) by trip from Shiprock Bridge to Mexican Hat; 2011. Error bars represent ± 1 SE. Letters represent comparisons among trips (Nemenyi post-hoc). Similar letters represent that significant differences did not exist and unlike letters indicate that significant differences were detected among comparisons.

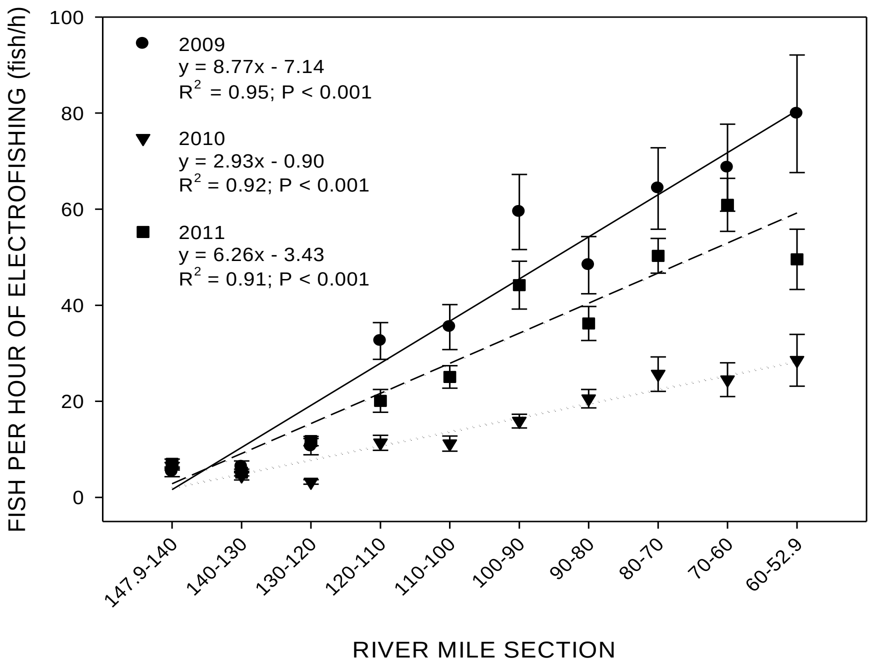

Figure 13. Juvenile channel catfish CPUE (fish/hour) by 10 river mile segments from Shiprock Bridge to Mexican Hat; 2009-2011. Error bars represent ± 1 SE.

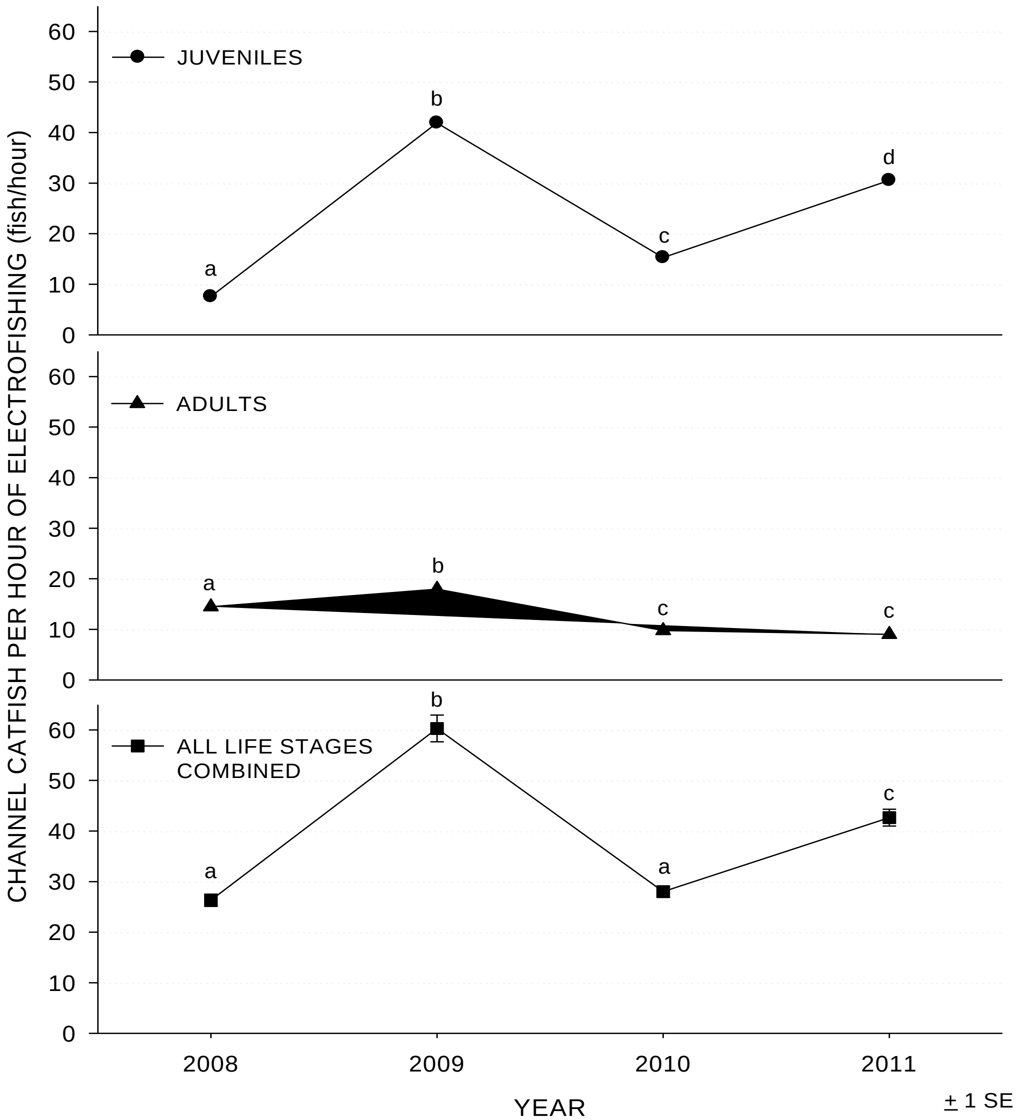

Figure 14. Channel catfish CPUE (fish/hour) from Shiprock Bridge to Mexican Hat; 2008 - 2011. Error bars represent ± 1 SE. Letters represent comparisons among trips (Nemenyi post-hoc). Similar letters represent that significant differences did not exist and unlike letters indicate that significant differences were detected among comparisons.

Channel catfish TL in 2011 ranged from 20 to 798 mm with a mean of 289 mm TL (Figure 15). The majority of measured channel catfish (60.7 %) were < 300 mm TL, 32.2 % were between 300 – 500 mm TL, and 7.2% were > 500 mm TL. Compared to previous years, and similar to the two adjacent upstream reaches, the majority of the size structure in 2011 was composed of juvenile and sub-adult fish. Larger adult channel catfish, 425 – 575 mm TL, composed 21.7 % of the total catch in 2011.

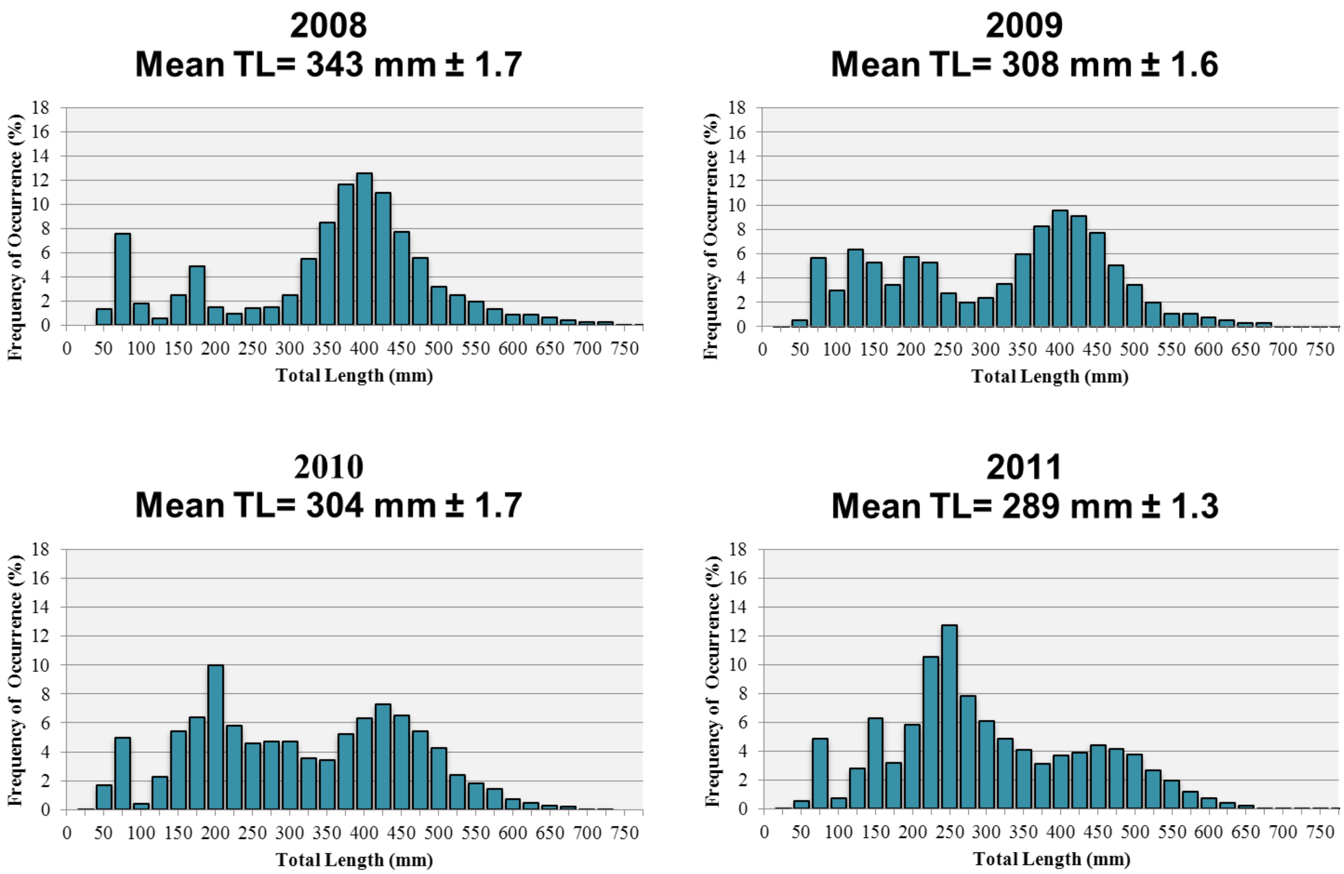

Figure 15. Mean TL (1 SE) and length frequency histograms by trip for channel catfish collected from Shiprock Bridge to Mexican Hat Utah; 2008-2011. The y-axis represents percentage (%) of catch and the x-axis represents total length.

Mean common carp CPUE 2011 was 0.3 fish/hour and varied little among the four trips (Figure 16). Mean CPUE in 2011 was signficantly lower than catch rates observed in all previous years (ANOVA; $F_{(3, 2,123)} = 97.370$; $p < 0.001$) (Figure 17). Similar to other sections, common carp were uncommon in our collections.

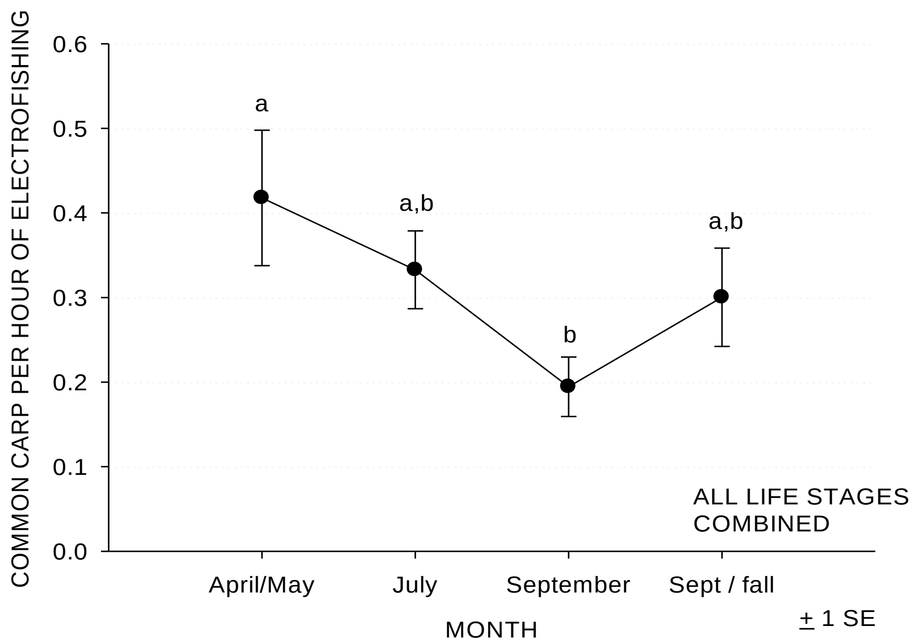

Figure 16. Common carp CPUE (fish/hour of electrofishing) during 2011 nonnative removal trips from Shiprock Bridge to Mexican Hat. Error bars represent + 1 SE. Letters represent comparisons among trips (Nemenyi post-hoc). Similar letters represent that significant differences did not exist and unlike letters indicate that significant differences were detected among comparisons.

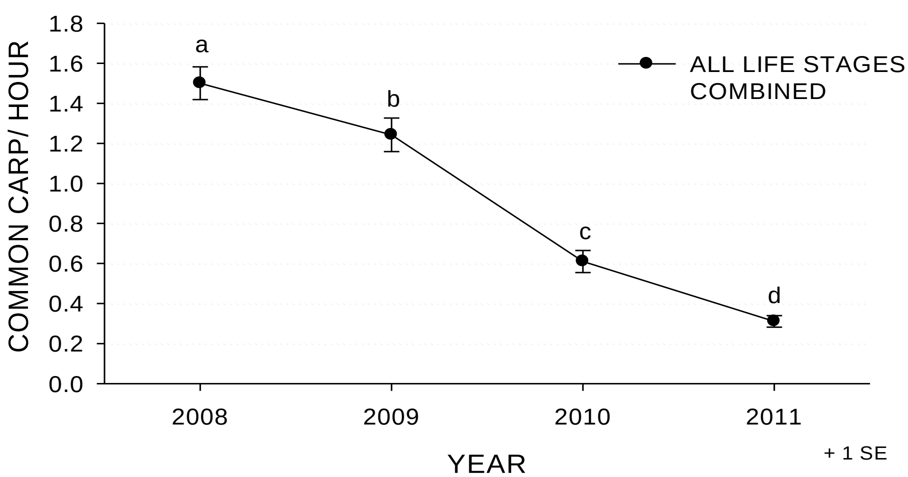

Figure 17. Common carp CPUE (fish/hour of electrofishing) during nonnative removal trips from Shiprock Bridge to Mexican Hat, 2008 – 2011. Error bars represent + 1 SE. Letters represent comparisons among trips (Nemenyi post-hoc). Similar letters represent that significant differences did not exist and unlike letters indicate that significant differences were detected among comparisons.

RARE FISH COLLECTIONS

A total of 1,748 Colorado pikeminnow and 1,576 razorback sucker were captured during nonnative removal trips from PNM Weir to Mexican Hat, Utah (Appendix A-3). Three hundred and eight Colorado pikeminnow and 386 razorback sucker were collected from PNM Weir to Hogback Diversion; 521 Colorado pikeminnow and 663 razorback sucker were collected from Hogback Diversion to Shiprock Bridge; and 919 Colorado pikeminnow and 527 razorback sucker were collected from Shiprock Bridge to Mexican Hat. These totals do not include rare fishes collected during annual sub-adult and adult fish community monitoring conducted by U.S Fish and Wildlife Service- Colorado Fishery Project but do include the rare fish collected during the tagging trip in early April from Shiprock Bridge to Mexican Hat. For analysis purposes, fish that were recaptured multiple times on an individual trip or throughout the year were included, but recaptures of an individual fish on the same day were excluded.

COLORADO PIKEMINNOW

All Colorado pikeminnow collected in 2011 were considered to be stocked fish. A total of 335 individual fish had PIT tags at time of capture. Recaptures ranged from 1- 3,080 days since first encounter. Fish were classified as first encounters when the fish was stocked in the river or collected and tagged in the river. The majority of these fish (85%, n= 284) were captured < 365 days since first encounter (Figure 18) and 22 fish were recaptured > 730 days since first encounter. Various age classes were collected dating back to 2005; however, the majority of recaptures were comprised of the 2010 year class (Table 2). These were likely recaptures of fish stocked in May 2011.

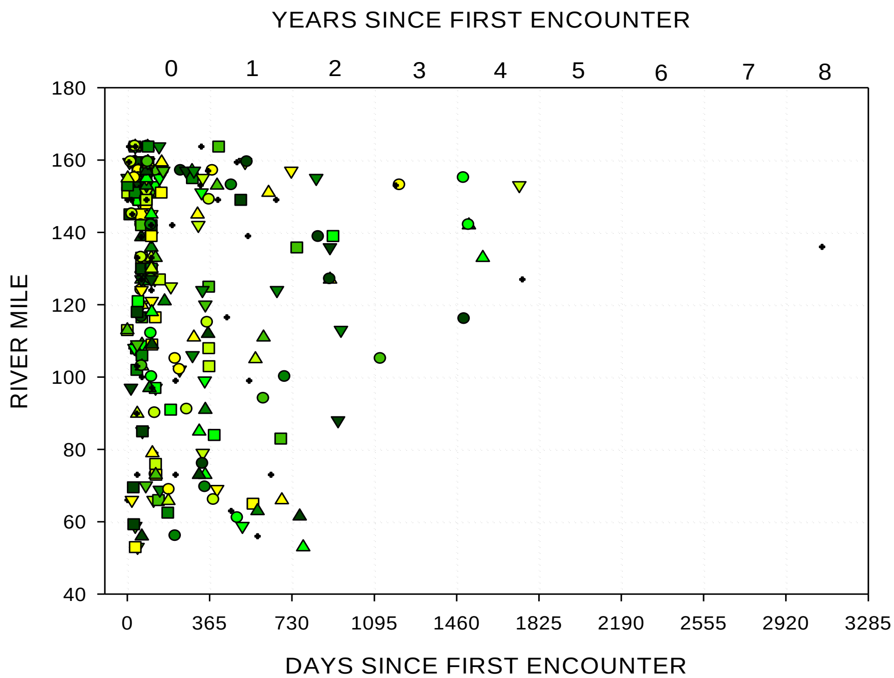

Figure 18. Days and years since first encounter versus river mile for Colorado pikeminnow encounters during nonnative fish removal trips conducted by NMFWCO; 2011. Different symbols and colors represent individual fish captures.

Table 2. Summary of Colorado pikeminnow, by known year class, collected during nonnative fish removal; 2011.

Year class	N
2005	7
2006	7
2007	10
2008	93
2009	584
2010	1,032

A total of 602 Colorado pikeminnow were implanted with a PIT tag at the time of capture. These newly implanted fish ranged in size from 128 – 504 mm TL, with a mean TL of 216 mm. Seven-hundred-thirty-one captures were not implanted with a PIT tag because they were < 150 mm TL. The mean TL of Colorado pikeminnow collected during our efforts in 2011 was 192 mm TL (range = 62 – 800 mm TL) (Figure 19). Fish < 150 mm TL composed 43.8% (n = 740) of the total catch while fish > 400 mm TL composed 1.6 % (n = 27) of the catch. Seventeen adult Colorado pikeminnow were collected including eight fish ranging from 450 – 500 mm TL and nine individuals > 500 mm TL. One individual Colorado pikeminnow with a TL of 800 mm was collected during the July trip. The crew that caught the individual did not have a PIT tag reader at time of capture so the fish was released without determination of a PIT tag.

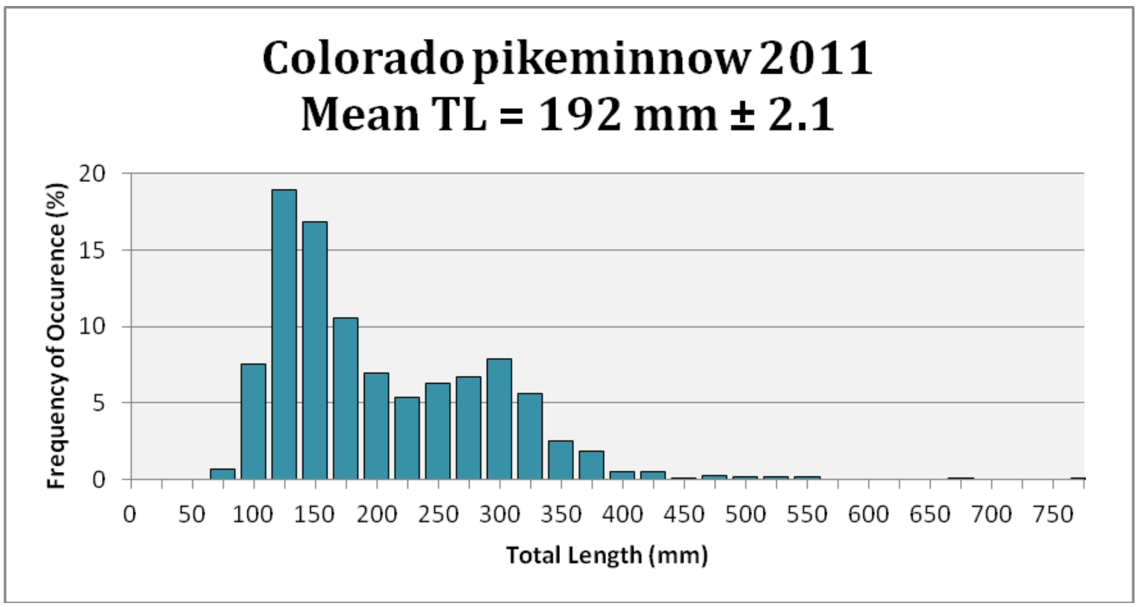

Figure 19. Mean TL (1 SE) and length frequency histogram for Colorado pikeminnow collected during intensive nonnative fish removal trips; 2011. The y-axis represents percentage (%) of catch and the x-axis represents total length.

RAZORBACK SUCKER

All razorback sucker collected in 2011 were considered to be stocked fish. Although 124 razorback sucker were lacking PIT tags at time of capture, we assumed these fish were stocked from Navajo Agricultural Products Industry (NAPI) ponds in 2006 and 2007 without tags. All 124 of these fish were implanted with a 134.2 kHz PIT tag and subsequently released. Various known age classes were recaptured dating back to 1999 with the majority (70%) of recaptures composed of the 2008 year class (Table 3).

Table 3. Summary of razorback sucker by age class collected during nonnative fish removal; 2011.

Year class	N
1999	7
2000	14
2001	43
2002	13
2003	6
2004	3
2005	2
2006	42
2007	205
2008	856
2009	31

Days in river since first encounter ranged from 1 – 3,971 days (Figure 20). Of the 1,349 razorback sucker that had a known stocking history, 68% (n=921) were recaptured < 1 year since first encounter and 5.9% (n=80) were recaptured > 5 years since first encounter. Three individuals were recaptured 10 years since first encounter.

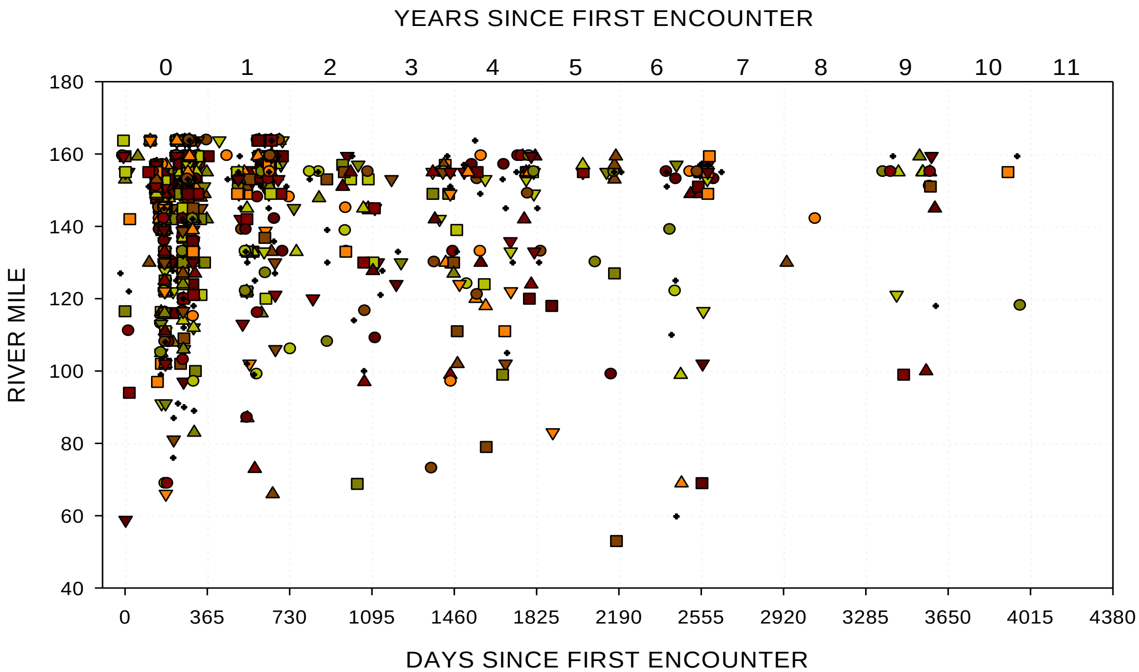

Figure 20. Days and years since first encounter versus river mile for razorback sucker encounters during nonnative fish removal trips conducted by NMFWCO; 2010. Different symbols and colors represent individual fish captures.

Mean razorback sucker TL in 2011was 410mm and sizez ranged from 292 – 615 mm TL (Figure 21). Of the 1,427 measured fish, 38% (n=537) were considered to be adult fish (>400mm TL). Of these adult fish, 85 fish were >500mm TL.

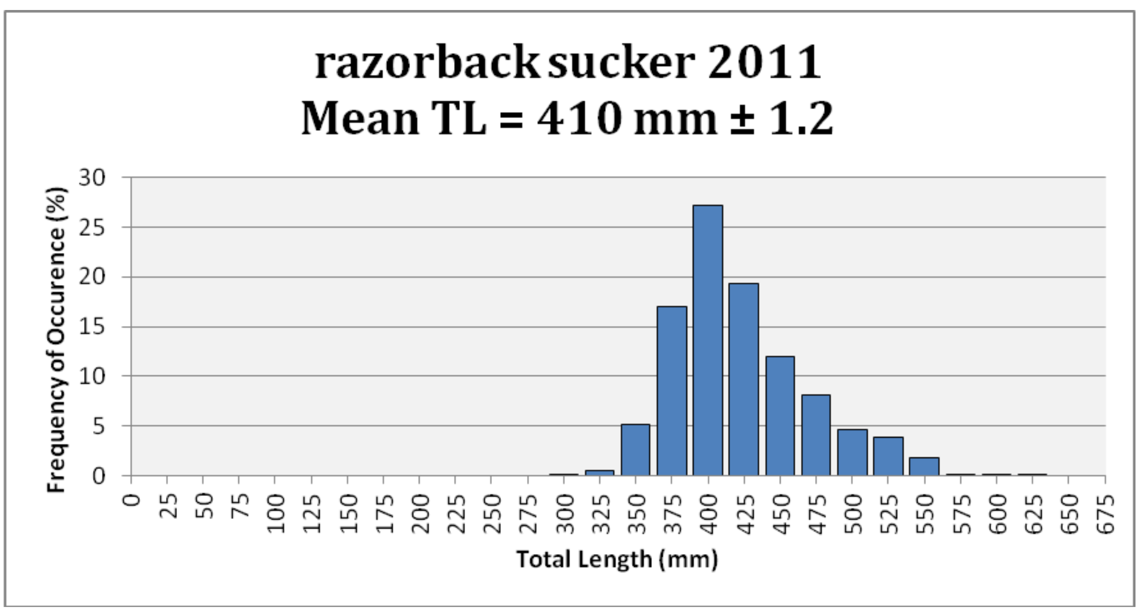

Figure 21. Mean TL (1 SE) and length frequency histogram for razorback sucker collected during intensive nonnative fish removal trips; 2010. The y-axis represents percentage (%) of catch and the x-axis represents total length.

DISCUSSION

Channel catfish CPUE from PNM Weir to Hogback Diversion in 2011was the highest observed annual CPUE since 2006. Channel catfish catch rates have shown some level of decline for the past six years until this increase in 2011. Previous declines in catch rates were likely the cumulative result of intensive removal efforts in this section and adjacent downstream sections. The increase in CPUE in 2011 was the result of the relatively high catch rates observed during the August trip. During the June trip only six channel catfish were collected, while 257 were collected during the August trip. The increase in catch rates in this section may be a result of fish moving from downstream areas of higher abundance and repopulating this study section. The selective fish ladder at PNM Weir also experienced an increase in channel catfish using the fish passage in late July and August, supporting the idea that upstream movement of channel catfish was occuring (James Morel personal communication). A small scale mark-recapture study conducted in 2003 concluded that both nonnative and native fishes move readily upstream of Hogback Diversion via a non-selective fish passage (Davis and Coleman 2004).

In 2003, nonnative removal efforts were expanded to include the Hogback Diversion to Shiprock Bridge section. Channel catfish abundance in this section was higher than the abundance of channel catfish at the start of removal in the adjacent upstream section, PNM Weir to Hogback Diversion, and after two years of removal, channel catfish CPUE was reduced to levels less than half of that at the initiation of removal. Channel catfish CPUE in 2011 was significantly lower than values observed in the first two years of removal but higher than values observed in 2010. Increases in juvenile channel catfish catch rates in 2011 influenced the observed increase in total channel catfish catch rates in this section. It is suspected that juvenile fish moved into the study reach from downstream. We suspect this emigration likely contributed to the variable catch rates and the resultant increase in CPUE. The increase in overall abundance in this section could also be the potential source of fish that moved into the PNM Weir to Hogback Diversion section. Although we analyzed each section independently, it is important to recognize the effect that high channel catfish abundance in downstream areas may have on our removal sections because of immigration/emigration.

Beginning in 2008, the expansion of removal efforts to include two passes per trip from Shiprock Bridge to Mexican Hat, UT, was expected to result in significant declines in channel catfish abundance river wide. However, channel catfish catch rates in 2011 significantly increased compared those values observed in 2008. Although an overall increase was observed, adult channel catfish catch rates significantly declined between 2008 and 2011. The increase in juvenile channel catfish catch rates that was observed 2009 and 2011 highly influenced the mean CPUE for all life stages combined. Although potentially alarming, these increases in juvenile channel catfish abundance were observed after the initial years of intensive removal in the two uppermost sections of our study (Davis and Duran 2009). It is unknown whether these increases in juvenile abundance are a result of previous year's flow regimes or a reproductive response to exploitation. An increase in smaller size classes of fish and a reliance on single year classes has been documented as a response to exploitation of channel catfish in the Mississippi River (Pitlo 1997). Regardless of the reason, it is our opinion that maintaining or even increasing intensive removal efforts from Shiprock Bridge to Mexican Hat in order to remove these juvenile fish prior to recruitment into adulthood, will be important in reducing riverwide abundance of channel catfish.

Data collected from a mark recapture study conducted by Utah Division of Wildlife Resources (UDWR) suggest that upstream movement by juvenile channel catfish may have been the cause of the increased abundance of juvenile channel catfish observed in our three study sections. In March 2009-2011, UDWR tagged channel catfish with anchor tags in the spring of each year from RM 52.9 to RM 3.0. (Darek Elverud personal communication). From 2009-2011 UDWR tagged several thousand channel catfish and 129 of these fish were subsequently recaptured during our nonnative removal trips conducted upstream of Mexican Hat in 2011. Of these captures, 56% (n = 72) were juvenile channel catfish. These 72 juveniles moved on average 49.5 river miles upstream. Similarly, in 2010, 32 channel catfish were recaptured in the upper removal sections and 21 were recaptured in upper removal sections in 2009. Although data are limited, channel catfish in the San Juan River can exhibit upstream movement and can potentially reoccupy upper removal sections in a relatively short time. Of the 1,334 channel catfish that we tagged from Shiprock Bridge to Mexican Hat in 2011, none were subsequently recaptured downstream of Mexican Hat during UDWR's nine trips through the lower canyon. This suggests that during 2011 channel catfish moved primarily upstream and if any tagged fish moved downstream they went undetected throughout the year.

Understanding the biology, including movement patterns and reproductive strategy of channel catfish is important to the management of this species in the San Juan River. Over the last several years we have observed significant increases in juvenile channel catfish catch rates near the Mancos River and McElmo Creek confluences. It appears that these two tributaries, or a combination of habitat parameters associated with the tributaries, could play an important role in this particular life stage of channel catfish and furthering our understanding of these relationships could be key in managing channel catfish in the San Juan River.

Equally important in the management of this species is an understanding of our capture techniques and the associated efficiency of capturing various life stages of our target species. Previous analyzes of our nonnative fish removal data by others suggest that our success in capturing channel catfish < 300mm TL may be limited (J. Morel unpublished data). A similar analysis of catch curves by 1 inch size groups suggests that channel catfish are fully recruited to our gear size once they attain a minimum length of 304-356mm TL (J. Davis unpublished data). Gerhardt and Hubert (1991) reported that in the Powder River drainage, the Ricker and Thompson-Bell model indicated that population structure and abundance of channel catfish would change considerably as exploitation rates (harvest) increased. They reported that an annual exploitation rate of 22% would result in a 75% reduction in overall abundance of fish $\geq$ 300 mm TL, and cause a substantial shift towards smaller individuals. New methods and gear types for effectively capturing juvenile channel catfish are being considered for future efforts and include the use of electric seines. By employing these new techniques it may be possible to focus our effort at removing size classes of channel catfish that we are currently ineffective in capturing and would likely result in an increase in our exploitation rates. As intensive nonnative removal in this section continues and juvenile and sub-adult channel catfish recruiting to a size effectively captured by our gear, we anticipate that our removal efforts in this section will result in a reduction in overall channel catfish abundance river wide in the next few years.

Initial shifts towards smaller fish may be important in long term suppression of channel catfish in the San Juan River by reducing overall reproductive potential and recruitment. Helms (1975) found that 1 of 10 channel catfish were sexually mature at 330 mm TL, compared to 5 of 10 at 380 mm TL. In addition, he found that channel catfish at 330 mm TL produced around 4,500 eggs/fish compared to the production of 41,500 eggs/fish at 380 mm TL. This shift towards smaller fish likely decreases our ability to effectively remove channel catfish as our exploitation rates for smaller sized fish is relatively low. Additionally, increased numbers of small channel catfish could also be a potential choking hazard for Colorado pikeminnow preying on these small fish.

Based on the length frequency histograms in all three removal sections, the majority of channel catfish captured in 2011 was composed of juvenile, sub-adult and newly recruited adult fish. A reduction in abundance of large channel catfish, 400-575 mm TL, may be important in not only limiting the reproductive potential of channel catfish in the San Juan River but may also limit overall predatory impacts on native fishes by channel catfish. Brooks et al. (2000) found that San Juan River channel catfish < 300 mm TL consumed almost exclusively macroinvertebrates and Russian olive fruits. Piscivory occurred most frequently in fish > 450 mm TL. Documentation of predation on endangered fishes during their study was not observed and was likely due to the relatively low number of endangered fishes in the San Juan River at the time of their study.

A more concerted effort by SJRIP researchers to quantify predation on native rare fishes by channel catfish has been initiated. A recent study by Patton et al. (unpublished data) failed to document channel catfish predation on Colorado pikeminnow based on pharyngeal tooth count. Based on their study they concluded that predation by channel catfish on Colorado pikeminnow in the San Juan River was absent or negligible. However, based on anecdotal evidence collected over the last 10 years, we have documented predation by channel catfish on both Colorado pikeminnow and razorback sucker. Although limited, these occurrences were opportunistically documented in the absence of a specific predation study (Davis and Furr 2007 and Jackson 2005). It is our opinion that although Patton et al. failed to document predation on rare fishes, our limited documentation of predation coupled with the high abundance of channel catfish in the San Juan River (Ryden 2011) may lend itself to higher levels of predation by channel catfish on the two rare fishes than has been documented. A better understanding on the predatory impacts of channel catfish on early life stages of razorback sucker and Colorado pikeminnow could be important in determining possible limiting factors for the lack of documented recruitment into juvenile life stages of these two species.

Common carp were once ubiquitous in the San Juan River and during 1991-1997 SJRIP studies were the fourth most abundant fish in electrofishing collections (Ryden 2000). Corresponding with the initiation of intensive removal, common carp abundance has been greatly reduced to a level of infrequent collection across all studies (Elverud 2010; Ryden 2010). Common carp catch rates in 2011 were < 0.6 in all three removal sections. Common carp CPUE from Shiprock Bridge to Mexican Hat was the lowest observed CPUE riverwide since intensive nonnative removal began.

Compared to channel catfish, significant reductions in common carp abundance estimates may be a result of the "catchability" of common carp under various sampling conditions. Common carp oftentimes exhibit electrotaxis (induced movement towards the anode) or oscillotaxis (thrashing motion or induced movement without orientation) when exposed to pulsed direct current (PDC). This behavior enables netters to easily identify and net common carp in turbid conditions. Conversely, channel catfish often exhibit tetany (electrically induced immobility with rigid muscles) when exposed to PDC and are slow in breaching the water surface (Kolz et al. 1998). This reaction makes it difficult for netters to effectively identify and capture channel catfish during turbid river conditions and likely affects capture efficiency.

Decreased common carp abundance may limit competitive interactions with native fishes and negative habitat modifications often associated with common carp (i.e. uprooting of aquatic plants causing increased turbidity, possible cause of noxious algae blooms by recycling of nutrients from silt substrates) (Cooper 1987). These decreases in abundance and the subsequent declines in carp biomass may allow for higher use of resources by native fishes with limited levels of interspecific competition.

In addition to our goal of removing large-bodied nonnative fishes, intensive nonnative removal trips have contributed to the gathering of information on rare fish distribution and abundance and may be used as a barometer to measure the success of current augmentation programs. The frequency and range of our trips, initially near stocking locations and now riverwide, provide the opportunity to gather large amounts of data on stocked fish and may be used to evaluate the success of individual stocking events.

We reported earlier on the relatively high number of razorback sucker that were recaptured near the stocking location at RM 158.6 (Duran and Davis 2010). These trends in distribution and abundance of stocked razorback sucker continued in 2011 with 64% of captures occurring within 10 RM's of the stocking site. However, razorback sucker will move large distances. Two razorback sucker captured in 2011 had been previously collected in Lake Powell and subsequently moved back into the mainstem San Juan River when the waterfall was inundated in the spring of 2011. One of those razorback sucker moved 53 miles in 20 days when it was captured by UDWR at RM 30 and then captured again by NMFWCO 19 days later at RM 83. This fish moved a total of 144 river miles upstream in 107 days and 53 river miles upstream in 19 days. Preliminary analyses of these data and apparent site fidelity exhibited by razorback sucker has prompted the Program to begin using multiple stocking locations upstream of the current stocking location and implementation of the "soft-release" method of stocking all razorback sucker that come from Uvalde National Fish Hatchery (Furr 2012 in draft).

Similar to previous years, Colorado pikeminnow captures were widely distributed in 2011. Although captures of adult Colorado pikeminnow in our collections were higher than previous years, more adults may persist in the San Juan River and our ability to detect these fish may be low. Discussions on new methodologies to detect the presence of adult Colorado pikeminnow have occurred and the Program has tested flat-plate or floating antennas which would remotely detect PIT tags both in the main stem river and tributaries of the San Juan River. In 2011, there were collections of Colorado pikeminnow that were previously captured or stocked in the San Juan River that were detected by the Colorado Division of Wildlife in Yellow Jacket Canyon and McElmo Creek using flat plate antennae. One of these Colorado pikeminnow was stocked in the Animas River in May 2011, and was detected in Yellow Jacket Canyon in the fall of 2011. This fish had moved over 100 miles in 4 months.

Mechanical removal of nonnative fishes, primarily channel catfish and common carp, continues to be supported by the SJRIP as one management tool for the recovery of Colorado pikeminnow and razorback sucker. Complete eradication of these species is not expected; however, using multiple pass sampling has and is expected to continue to reduce abundance to manageable levels. By reducing abundance and biomass of these species, spatial and trophic interactions with common and rare native fishes should be reduced and may result in improved post-stocking survival of stocked rare fishes. Collecting data on growth, distribution and abundance of rare fishes in conjunction with intensive nonnative fish removal continues to supplement monitoring data of these two species and will assist researchers with future management decisions and assessing progress towards recovery.

SUMMARY AND CONCLUSIONS

PNM WEIR TO HOGACK DIVERSION (RM 166.6 – 159.0)

- A total of 263 channel catfish and 21 common carp were collected during two removal trips in 2011.
- Channel catfish CPUE in 2011 was the highest CPUE observed since 2006.
- Channel catfish abundance twice that observed in 2010 with half the number of trips being conducted in 2011.
- Common carp CPUE in 2010 was similar to that observed in 2008-2010 but was significantly lower ($p < 0.05$) than values observed from 2001-2007.
- Common carp were uncommon in collections.

HOGBACK DIVERSION TO SHIPROCK BRIDGE (RM 158.8 – 147.9)

- A total of 741 channel catfish and 36 common carp were collected during three removal trips in 2011.
- Channel catfish CPUE in 2011 was similar to values observed from 2005-2010 but were significantly ($p < 0.001$) lower than values observed from 2003-2004.
- Excluding 2009, juvenile CPUE in 2011 was higher than values observed from 2007-2010.
- Common carp CPUE in 2011 was significantly ($p < 0.05$) lower than values observed from 2003-2009.
- Common carp were uncommon in collections.

SHIPROCK BRIDGE TO MEXICAN HAT, UTAH (RM 147.9 – 52.9)

- A total of 28,877 channel catfish and 207 common carp were removed during four (8 passes) removal trips in 2011.
- Juvenile channel catfish CPUE, by trip, in 2011 ranged from 19 to 42 fish/hour of electrofishing.
- Juvenile channel catfish CPUE significantly ($p < 0.001$) increased downstream of river mile 120.
- 2011 channel catfish CPUE, all life stages combined, was significantly higher than CPUE values observed in 2008 and 2010 but were significantly ($p< 0.001$) lower than values observed in 2009.
- Population estimate for adult channel catfish was 18,111 (95% CI = 15,220-21,002; CV=7.98%, SE=1,446).
- Common carp CPUE was < 0.5 fish/hour during each of the four removal trips.
- Common carp were uncommon in collections.

RARE FISH CAPTURES

- A total of 1,748 Colorado pikeminnow and 1,576 razorback sucker were encountered during 2011 sampling from RM 166.6 – 52.9.
- Majority of razorback sucker encounters were documented within 10 RM's of the stocking location at RM 158.6.
- Twenty-seven individual Colorado pikeminnow > 400 mm TL were collected in 2011.
- One individual Colorado pikeminnow with a TL of 800 mm was captured.

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Appendix A-1. Mean discharge, effort and total count of major species collected during intensive non-native removal efforts from PNM Weir to Hogback Diversion, 2011. Species listed by the first three letters of the Genera and first three letters of Species (i.e. *Ptychocheilus lucius = Ptyluc).* [1] Mean discharge from USGS gauge #09368000 near Shiprock, New Mexico.

Trip	**Discharge[1] (ft^3/sec)**	**Effort (hours)**	***Ptyluc***	***Xyrtex***	***Ictpun***	***Cypcar***	***Micsal***	***Ameiurus spp***	***Saltru***
June 21 – 23		12.8	119	179	6	2	1	0	45
August 16 – 18		17.7	189	207	257	19	3	9	7
Totals		**30.6**	**308**	**386**	**263**	**21**	**4**	**9**	**52**

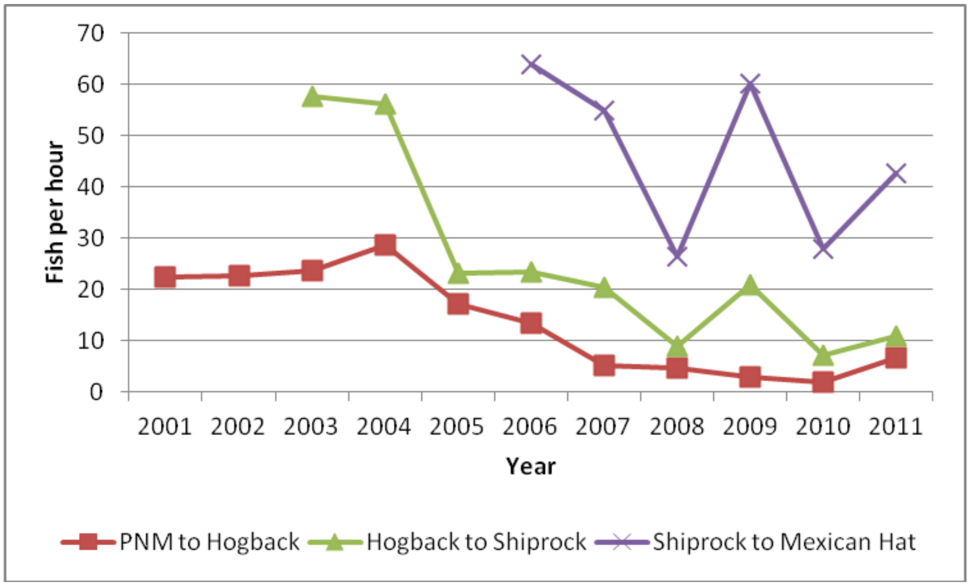
Appendix A-2. Mean discharge, effort and total count of major species collected during intensive non-native removal efforts from Hogback Diversion to Shiprock Bridge, 2011. [1] Mean discharge from USGS gauge #09368000 near Shiprock, New Mexico.

Trip	**Discharge[1] (ft^3/sec)**	**Effort (hours)**	***Ptyluc***	***Xyrtex***	***Ictpun***	***Cypcar***	***Micsal***	***Ameiurus* spp**	***Saltru***
March 22-24	728	19.9	12	277	9	4	0	0	13
July 6-8	1,593	21.7	301	169	333	17	2	22	38
August 9-11	451	26.2	208	217	399	15	5	14	**7**
Totals		**67.8**	**521**	**663**	**741**	**36**	**7**	**36**	**58**

Appendix A-3. Mean discharge, effort and total count of major species collected during intensive non-native removal efforts from Shiprock Bridge to Mexican Hat, Utah; 2011. Endangered fish were not collected by upstream boats (n/a). [1] Mean discharge from USGS gauge #09371010 near Four Corners, Colorado.

Trip	Discharge[1] (ft^3/sec)	Effort (hours)	*Ptyluc*	*Xyrtex*	*Ictpun*	*Cypcar*	*Micsal*	*Ameiurus* spp	*Saltru*
Tagging Trip									
April 7; 12-17	548								
Totals for trip		**57.5**	**99**	**109**	**1,875**	**22**	**0**	**10**	**8**
April 28 – May 6									
Downstream boats		86.7	118	191	4,634	37	1	33	16
Upstream boats	489	82.7	1	n/a	3,393	33	0	10	4
Totals for trip		**169.4**	**119**	**191**	**8,027**	**70**	**7**	**43**	**20**
July 19 - 27									
Downstream boats		86.3	357	114	2,892	38	3	39	11
Upstream boats	1,020	87.4	10	6	1,565	23	0	30	6
Totals for trip		**173.7**	**367**	**120**	**4,457**	**61**	**3**	**69**	**17**
September 1 - 9									
Downstream boats		91.2	301	106	3,463	18	7	53	0
Upstream boats	668	86.2	1	n/a	3,464	15	3	38	0
Totals for trip		**177.4**	**302**	**106**	**6,927**	**33**	**10**	**91**	**0**
****September 21 - 29**									
Downstream boats		62.6	230	123	4,454	22	4	36	1
Upstream boats	588	92.6	n/a	n/a	4,928	19	0	40	0
Totals for trip		**155.3**	**230**	**123**	**9,382**	**41**	**4**	**76**	**1**
Totals (excluding tagging trip)		**676**	**1,018**	**540**	**28,793**	**205**	**24**	**279**	**38**

** Nonnative removal trip conducted in conjunction with annual sub-adult and adult fish community monitoring. Downstream boats sampled using standardized sampling protocols as defined in *San Juan River Monitoring Plan and Protocols (Propst et al. 2006)*. Downstream boats sampled in one river mile increments, with two of every three river miles sampled. When possible, upstream boats sampled all river miles and did not skip the same miles as the downstream boats.



Appendix B. Channel catfish CPUE (fish/hour of electrofishing) by individual removal section. The years 2007 and 2008 are included in the Shiprock to Mexican Hat section for comparison although only one trip per year was completed.